

## Inspire Form 실전 (3) - Stamping Material

한국알테어 • 김성문 기술사 • 2019-05-15

## 웨비나 순서

- Altair Inspire Platform
- Material Definition



# Altair Inspire Platform



# Altair Inspire - From Studio To Manufacturing

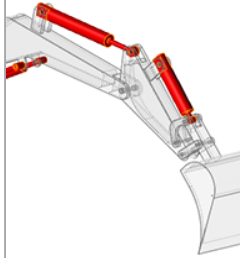
Studio



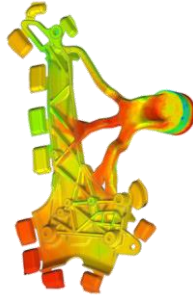
Structures



Motion

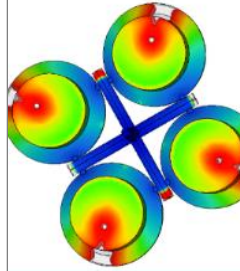


Casting

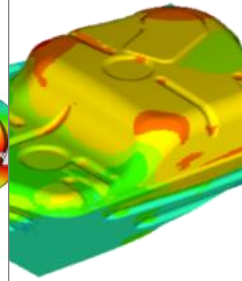


*coming soon*

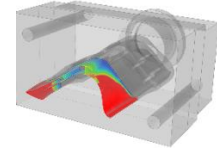
Molding



Forming



Extrusion



*coming soon*

Additive



The industry's most powerful and intuitive solution for design engineers to create high performing and manufacturable products.



## What Is Altair Inspire Form?

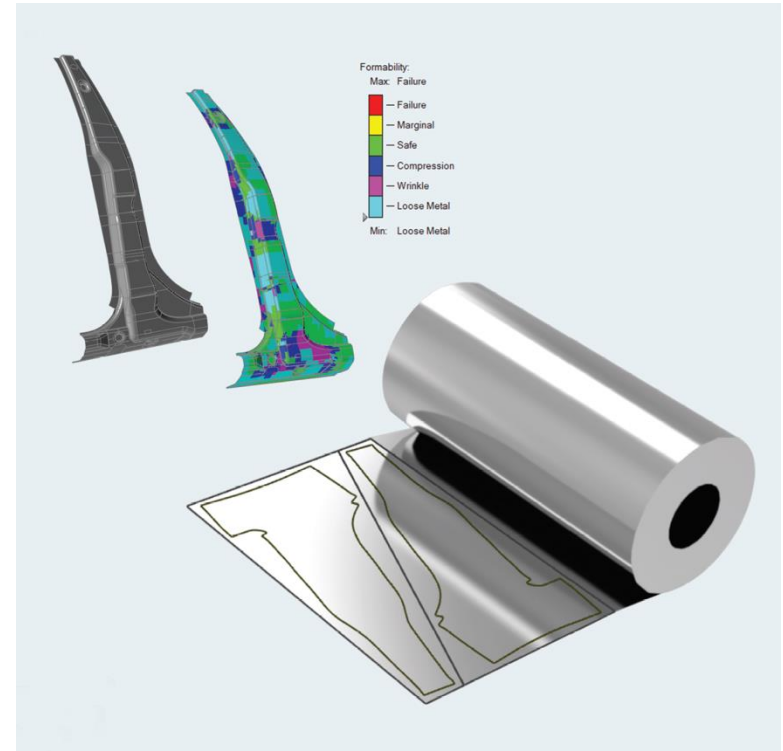
A streamlined stamping simulation software to

- Design better products with early check for forming feasibility
- Reduce scraps and improve material utilization
- Improve productivity with accurate formability analysis
- Optimize the process through single and multi-stage virtual tryout



## Feasibility (1-step)

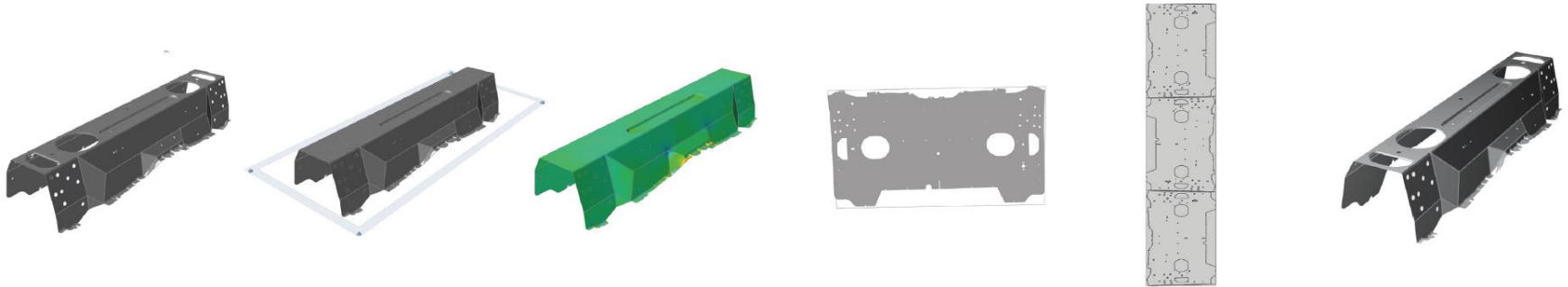
1. Use part CAD – no meshing required
2. Material database with US, Japanese and European standards
3. Automatic orientation to minimize undercuts
4. Apply blank holding force and drawbeads
5. Visualize thinning, formability, strains
6. Automatic blank fit and nesting to save material cost



## Feasibility Workflow

Quickly and reliably check the formability of the part early in the design phase by predicting potential for splits, wrinkles and loose metal.

The geometry of the flat blank can be automatically fitted inside regular shapes such as rectangle and trapezoid as well as nested on a sheet coil for maximum material utilization.



Import Geometry

Set Up Model

Analyze Formability

Flatten & Fit Blank

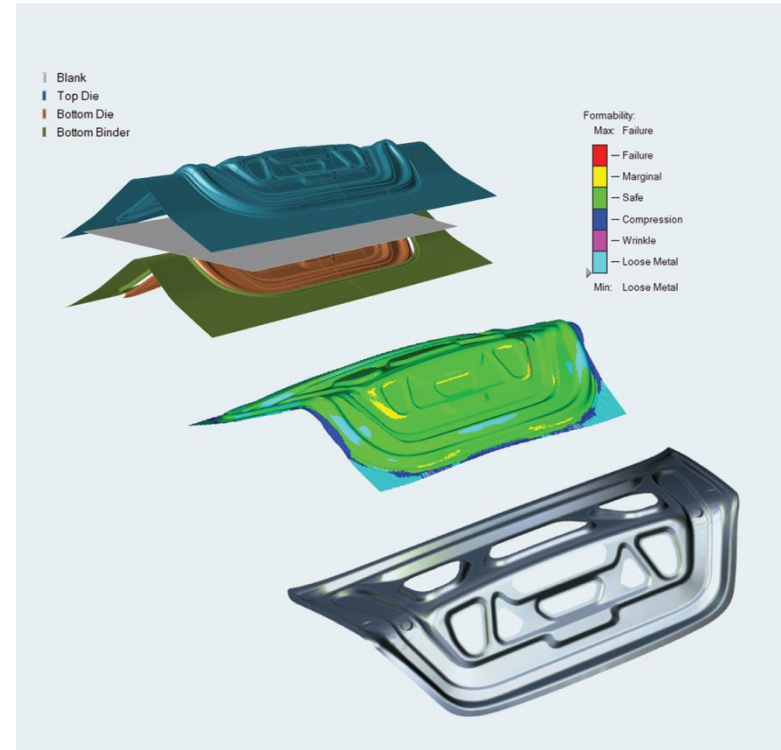
Nest Blanks

Form



## Virtual Tryout (Incremental)

1. Intuitive and efficient environment for single and multi-stage stamping simulation.
2. Highly scalable solver for accurate forming and springback analyses
3. Thinning, strain, stress, failure contours and Forming Limit Diagram
4. Plot of tool force versus stroke
5. Callouts to view results history at any location

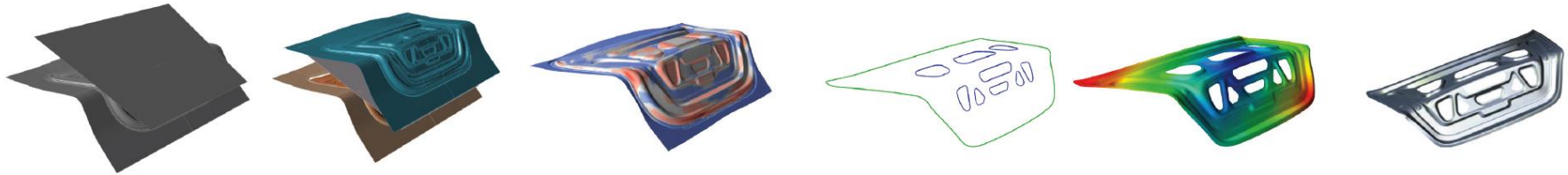




## Tryout Workflow

Intuitively setup complex stamping processes including gravity, draw, redraw, flanging and springback with all tools and blanks.

Iterate on blank holder force and drawbead location and force to improve part quality.



Import Model

Set Up Drawing

Analyze Drawing

Set Up Trimming & Springback

Analyze Springback

Form

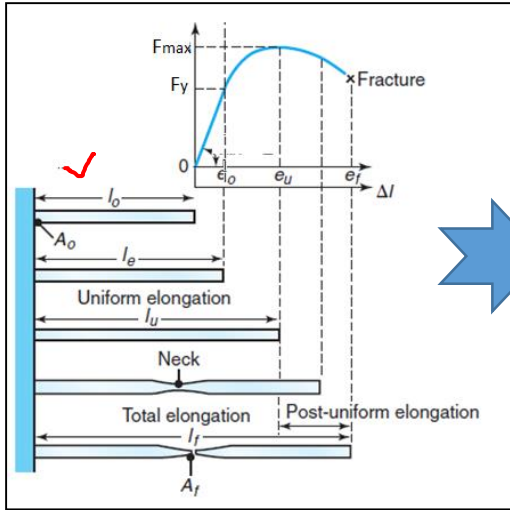


# Material Test

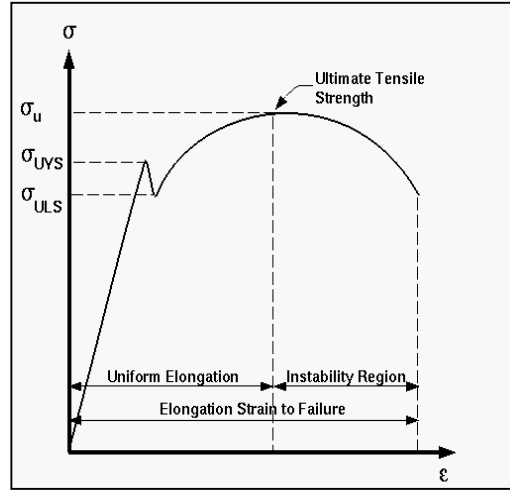


# Sheet Material Behavior

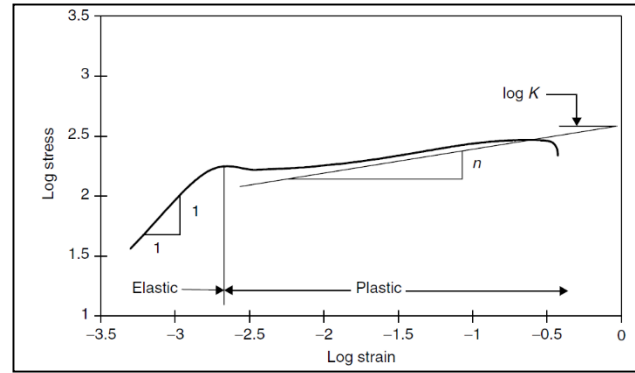
- Sheet Material Behavior - Tensile test



Force Vs Deflection



Stress Vs Strain curve



Fit to standard equations

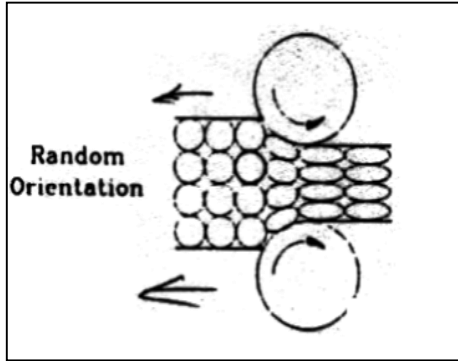
$$\sigma_T = K \epsilon_T^n \quad \text{or} \quad \sigma_T = \sigma_0 + K \bar{\epsilon}^n$$

$$\sigma = K (\epsilon_0 + \bar{\epsilon})^n$$

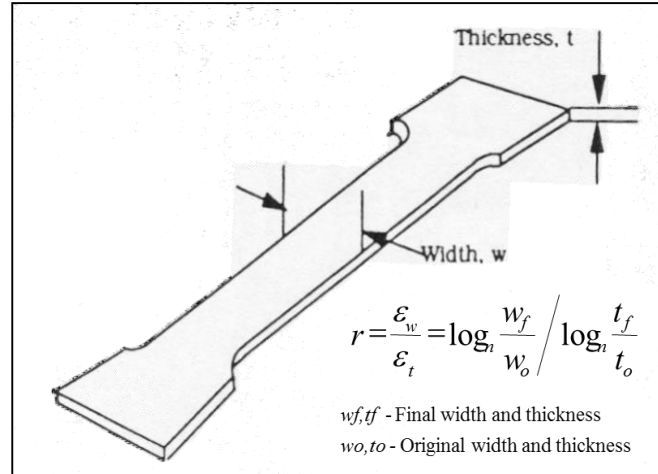


# Sheet Material Behavior

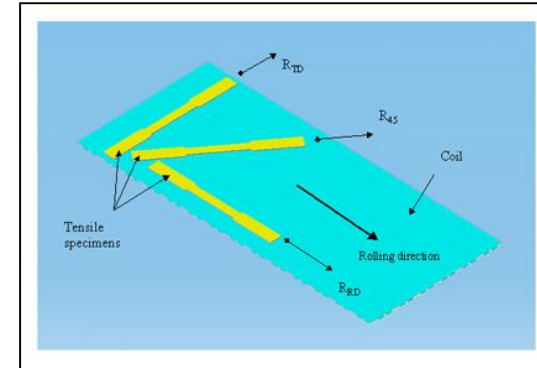
- Sheet Material Behavior - Anisotropy



Grain oriented along rolling



Plastic strain ratio R from Tensile test

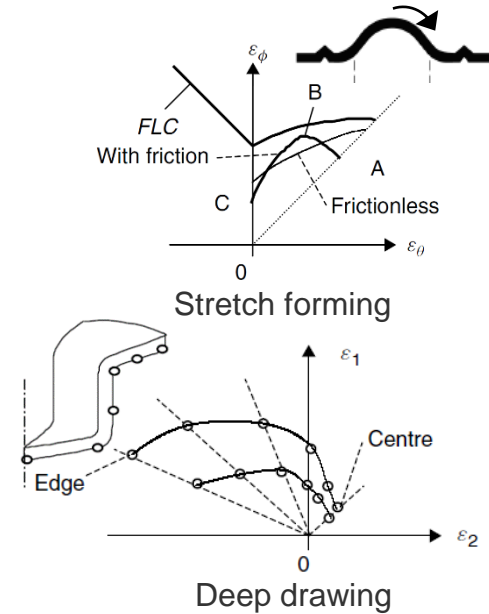
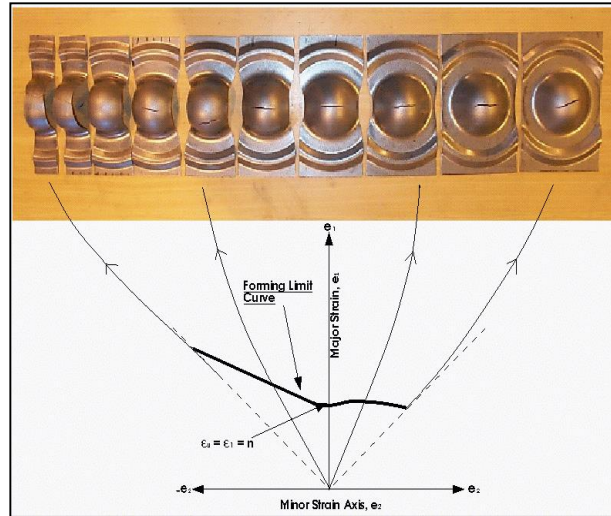
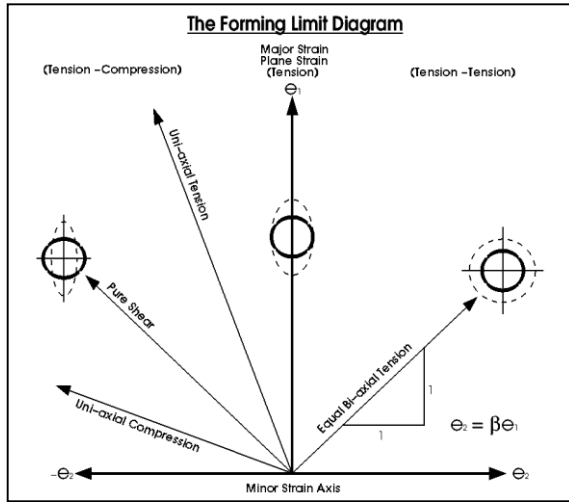


Quantify anisotropy in sheet metal



# Sheet Material Behavior

## • Sheet Material Behavior - Forming Limit diagram



- A plot of Major and Minor strain
- Location on the plot gives information of mode of deformation

- Limit curve obtained from experiments gives the forming limit of material beyond which it fails.

- Captures all deformation modes

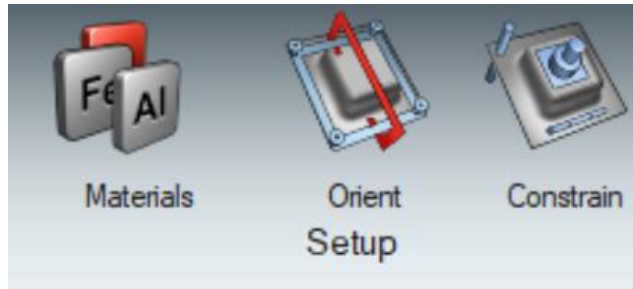


# Inspire Form Material Definition

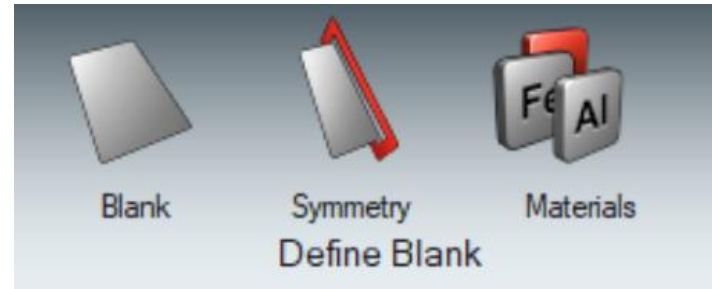


## Feasibility / Tryout: Materials

- **Materials** - Create a material that is based on an existing predefined material in the System Library.
- **Orient** - Use the Orient tool to orient the stamping direction for a part.
- **Constrain** - Use the Constrain tool to create pin, drawbead, and blankholder constraints for analysis.



✓ Feasibility

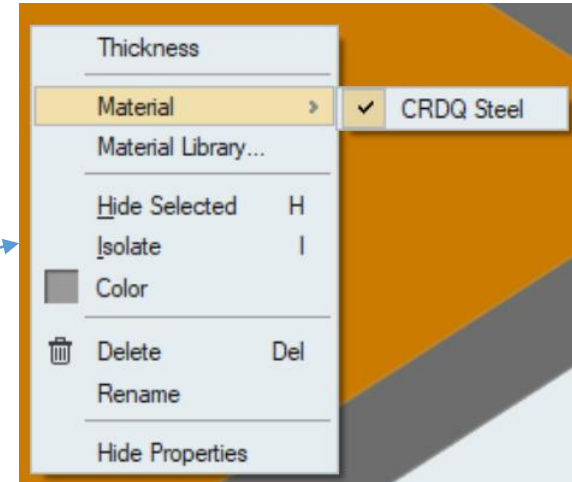
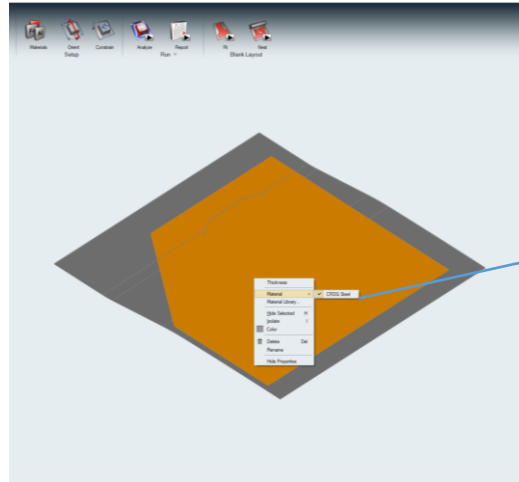
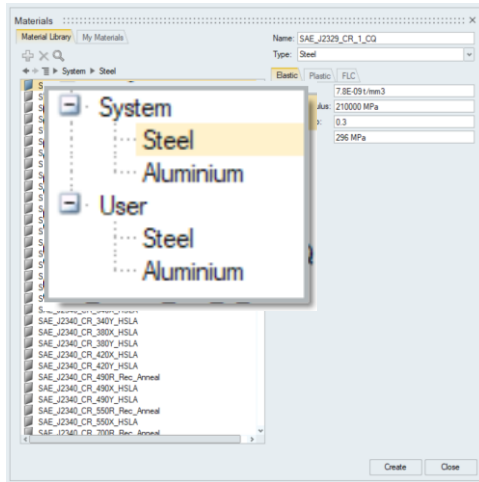


✓ Tryout



# Material Database(1) Material DB

- **Create and Edit Materials Based on the System Library**
  - Create a material that is based on an existing predefined material in the System Library.

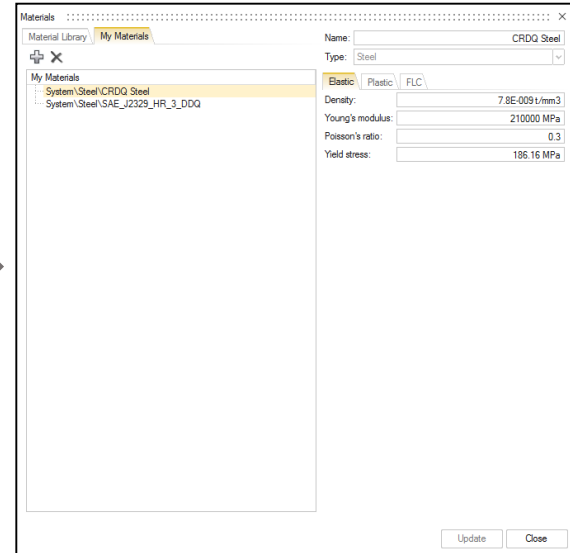
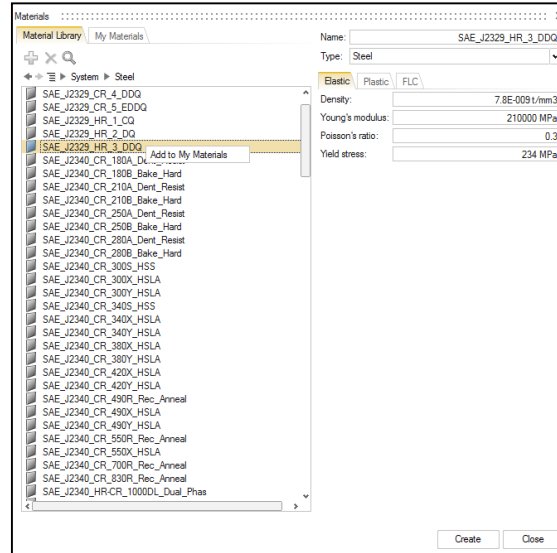
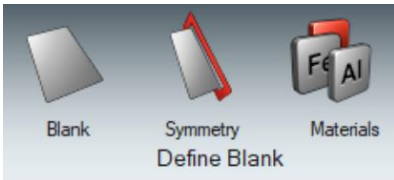




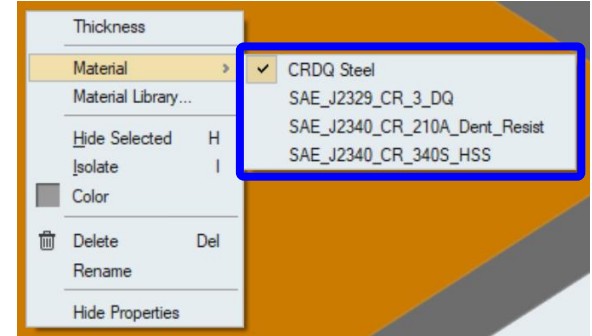
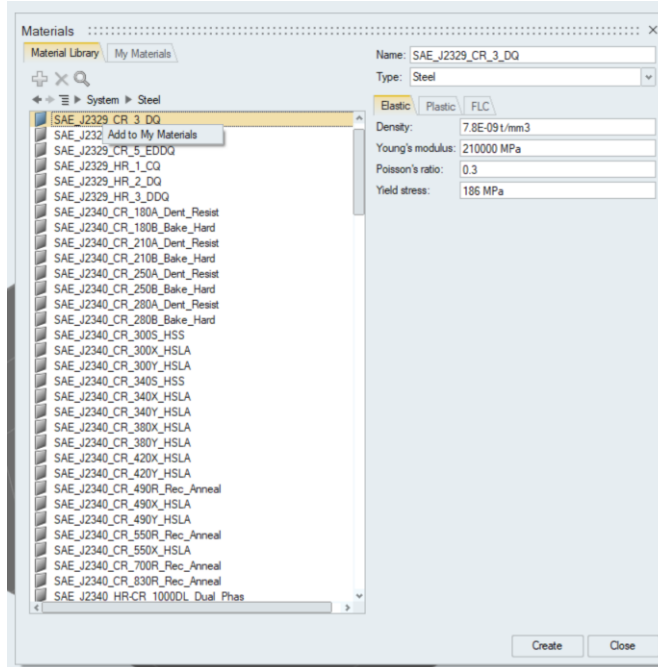
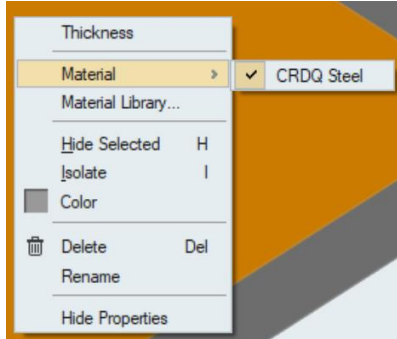
# Material Database(1) Material DB



- **Create and Edit Materials Based on the System Library**
  - **Feasibility Ribbon > Setup Tool > Materials > Material Library Tab > Select the material**
  - Click Materials ribbon under Set Up to open the material library
  - Select a material from the material library and right click to **add to My Materials**
  - Added material can be accessed by right mouse click on the part and assigned



# Material Database(1) Material DB

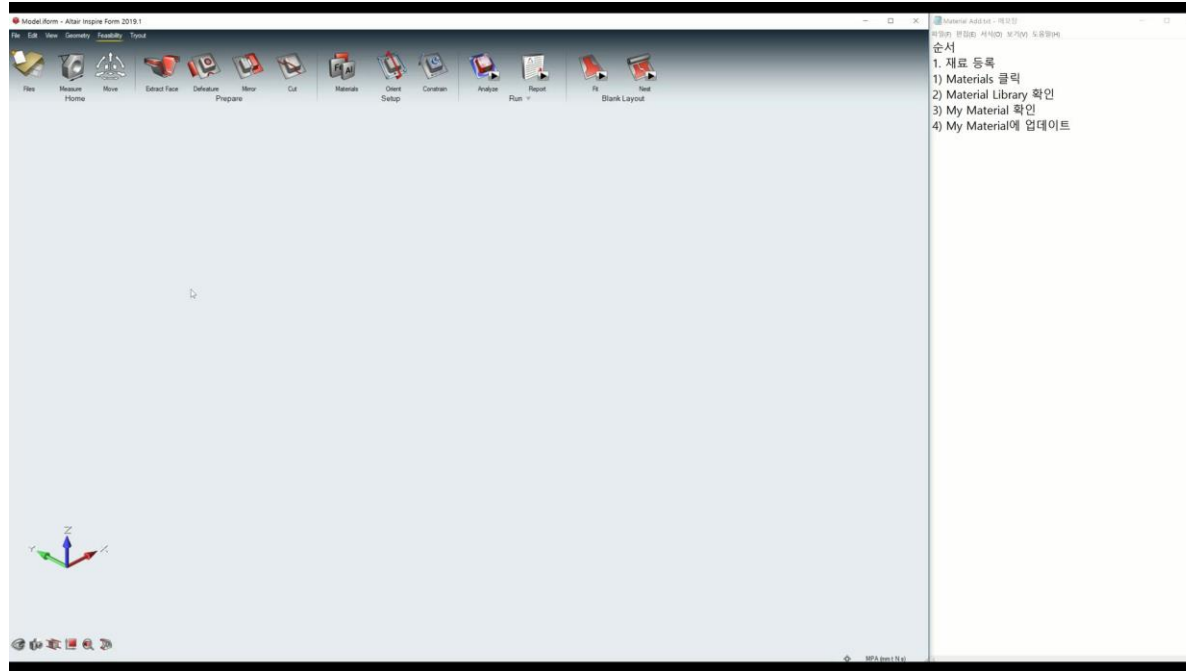


# Material Database(1) Material DB

The image displays three overlapping screenshots of a software interface for managing a material database. The top-left screenshot shows a tree view of materials under 'My Materials', including System and User materials. The top-right screenshot shows a context menu for a selected material, with options 'Add to User Material Library' and 'Delete from My Materials'. The bottom screenshot, highlighted with a red border, shows a detailed view of the material 'Test-20190415' with its properties: Name, Type (Steel), Elastic/Plastic/FLC tabs, Density (7.8E-09 t/mm3), Young's modulus (210000 MPa), Poisson's ratio (0.3), and Yield stress (186.16 MPa).




# Material Database(1) Material DB Demo

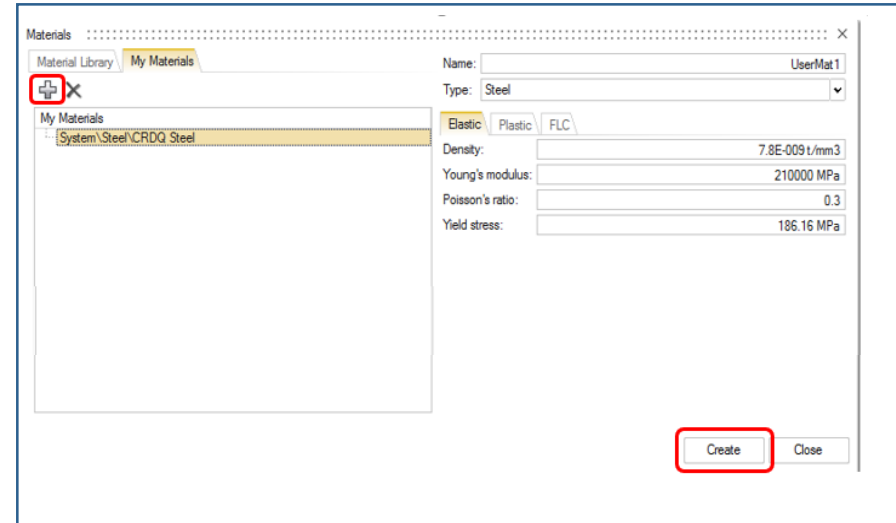


▶ 재생 시간: 2분 49초



## Material Database(2) Material Create

- **Create and Edit Materials from “My Materials” tab**
- Also user can create a material under **My Materials tab** and assign to part
- Click on the symbol  and Create button to create a new material
- Enter a **Material Name**
- Enter the **Elastic, Plastic and FLC** data and click **Create**
- After creating the material user can also update the values at any time



# Elastic

Materials

Material Library: My Materials

Name: UserMat1

Type: Steel

Property	Value
Density:	7.8E-09 t/mm3
Young's modulus:	210000 MPa
Poisson's ratio:	0.3
Yield stress:	186.16 MPa

Buttons: Create, Close

Material Property Settings:

- Tab: Elastic
- Density: 7.8E-09 t/mm3
- Young's modulus: 210000 MPa
- Poisson's ratio: 0.3
- Yield stress: 186.16 MPa



# Plastic

Materials

Material Library: My Materials

Name: UserMat1

Type: Steel

My Materials

- System\Steel\CRDQ Steel

Elastic Plastic FLC

Stress-Strain: Power Law (True)

Yield stress: 186.16 MPa

Tensile stress: 315.78 MPa

Strength coefficient: 549.03 MPa

Strain hardening: 0.22

Uniform elongation: 0

R00: 1.6

R45: 1.6

R90: 1.6

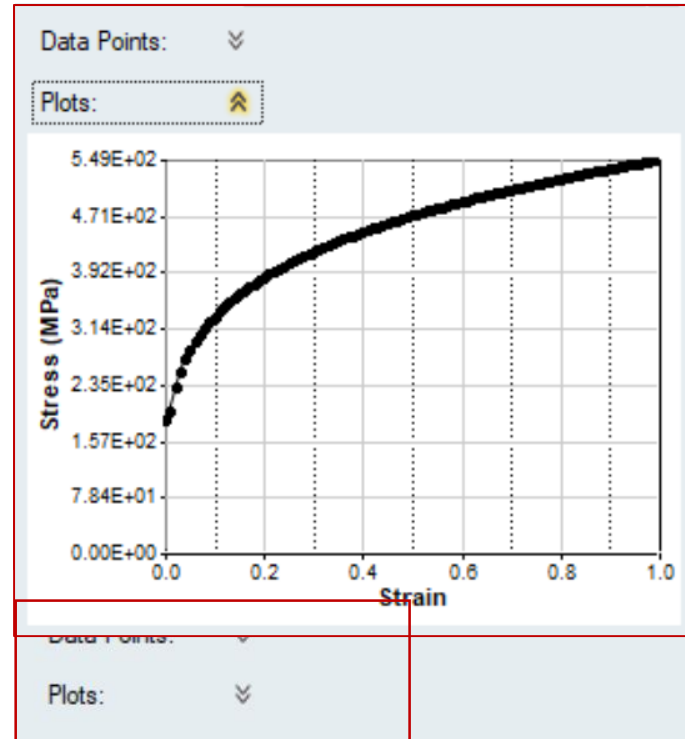
Yield criterion: Hill 1948

Exponent (n): 2.0

Data Points: ⌵

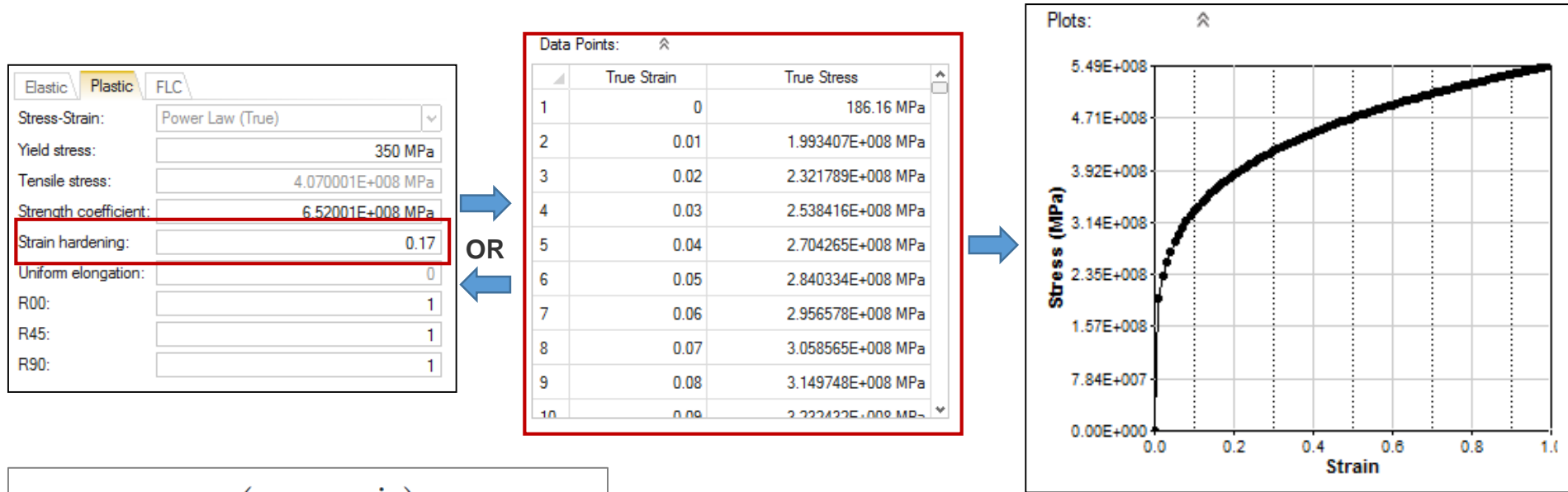
Plots: ⌵

Create Close



## Material Database(2) Material Create

- **Create and Edit Materials from “My Materials” tab**
  - User can enter the **Plastic data or Data Points (Engineering or True Stress-Strain values based)**
  - Once we **enter the values and create a material Stress Strain plot gets updated**




$$\sigma = (a + b\varepsilon_p^n) \left( 1 + c \ln \frac{\dot{\varepsilon}}{\dot{\varepsilon}_0} \right) (1 - (T^*)^m)$$





# Material Database(2) Material Create

- **Create and Edit Material using Stress Strain curve's data**
  - Click **My Materials** Tab inside materials window
  - Add a material by clicking on the  option
  - Load the excel file to **Data Points**

Uniaxial tension test data						
Tensile direction from RD	Young's Modulus (GPa)	*s <sub>0.2</sub> (w) (MPa)	*s <sub>1.0</sub> (w) (MPa)	Tensile Strength (MPa)	Uniform Elongation (%)	R-Value
0 <sup>0</sup>	186	684,2	870,8	1017,2	9,4%	0,691
15 <sup>0</sup>	187	676,9	862,6	NA	NA	0,760
30 <sup>0</sup>	186	669,9	854,5	NA	NA	0,888
45 <sup>0</sup>	191	676,6	863,4	1007,3	9,0%	1,050
60 <sup>0</sup>	197	685,2	873,8	NA	NA	1,080
75 <sup>0</sup>	204	691,4	886,3	NA	NA	1,020
90 <sup>0</sup>	208	701,5	898,0	1052,3	9,4%	0,959

## User Table data

Plastic Strain	True stress
0	670.0813
0.005	781.3333633
0.01	863.2312874
0.015	916.8322885
0.02	955.3279273
0.025	984.1043743
0.03	1006.215309
0.035	1023.609047
0.04	1037.597375
0.045	1049.089413
0.05	1058.726585
0.055	1066.967202
0.06	1074.142058
0.065	1080.492057
0.07	1086.194154
0.075	1091.379477
0.08	1096.146098
0.085	1100.568094
0.09	1104.702016
0.095	1108.591538
0.1	1112.270797
0.11	1119.101303
0.12	1125.353035
0.13	1131.13382
0.14	1136.520361



The screenshot shows the 'Materials' window in Altair Inspire. The 'My Materials' tab is active, and a new material 'Steel\UserMat1' is being created. The 'Data Points' table is visible, containing the following data:

	True Strain	True Stress
1	0	670.081 MPa
2	0.005	781.333 MPa
3	0.01	863.231 MPa
4	0.015	916.832 MPa
5	0.02	955.328 MPa
6	0.025	984.104 MPa
7	0.03	1006.22 MPa
8	0.035	1023.61 MPa
9	0.04	1037.6 MPa
10	0.045	1049.09 MPa
11	0.05	1058.73 MPa
12	0.055	1066.97 MPa
13	0.06	1074.14 MPa
14	0.065	1080.49 MPa
15	0.07	1086.19 MPa
16	0.075	1091.38 MPa

# Material Database(2) Material Create Demo

## Step 1: 측정 항목 확인


Uniaxial tension test data						
Tensile direction from RD	Young's Modulus (GPa)	*S <sub>0.2</sub> (w) (MPa)	*S <sub>1.0</sub> (w) (MPa)	Tensile Strength (MPa)	Uniform Elongation (%)	R-Value
0 <sup>0</sup>	186	684,2	870,8	1017,2	9,4%	0.691
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45 <sup>0</sup>	191	676,6	863,4	1007,3	9,0%	1.050
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75 <sup>0</sup>	204	691,4	886,3	NA	NA	1.020
90 <sup>0</sup>	208	701,5	898,0	1052,3	9,4%	0.959

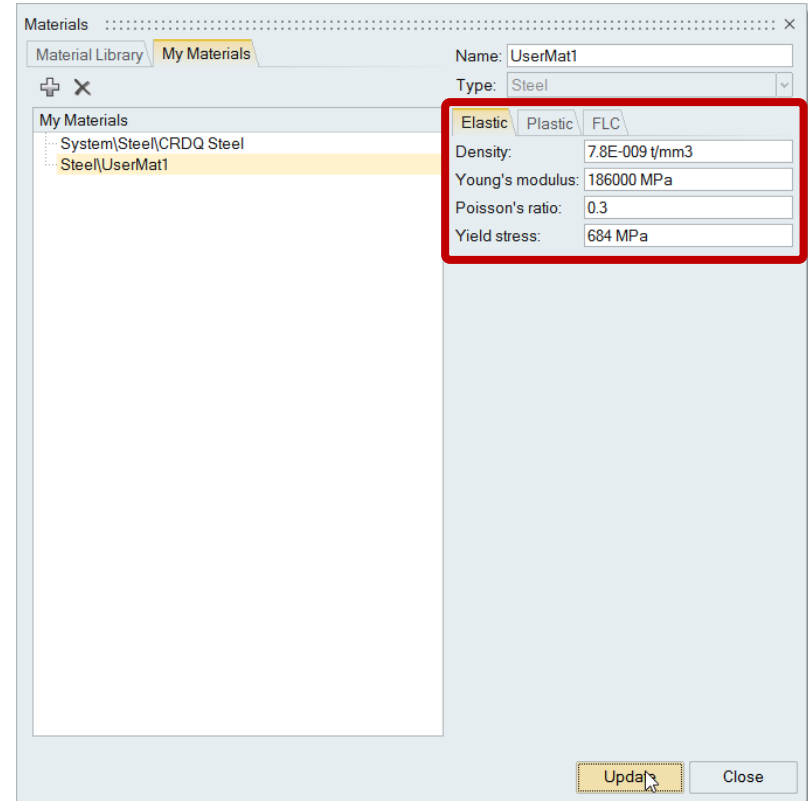
Plastic Strain	True stress
0	670.0813
0.005	781.3333633
0.01	863.2312874
0.015	916.8322885
0.02	955.3279273
0.025	984.1043743
0.03	1006.215309
0.035	1023.609047
0.04	1037.597375
0.045	1049.089413
0.05	1058.726585
0.055	1066.967202
0.06	1074.142058
0.065	1080.492057
0.07	1086.194154
0.075	1091.379477
0.08	1096.146098
0.085	1100.568094
0.09	1104.702016
0.095	1108.591538
0.1	1112.270797
0.11	1119.101303
0.12	1125.353035
0.13	1131.13382
0.14	1136.520361



## Material Database(2) Material Create Demo

### Step 2

- a) Click **My Materials** Tab inside materials window
- b) Add a material by clicking on the  option
- c) Enter **Name** and choose **Type**.
- d) Use **Elastic** tab to fill Elastic material data. By default it is populated with steel data.
- e) Define **Youngs Modulus** as **186000 Mpa**.
- f) Define **Yield stress** as **684 Mpa**.
- g) Click **Create**



# Material Database(2) Material Create Demo

## Step 3

- Enter **Plastic** Tab
- Set **Stress – Strain:** to Data points (True)
- Open **Data Points**, Select a field, Right click and **Pick Clear All** to empty table.
- Copy Data** (Ctrl+C) from excel file (data from 2 columns), paste (Ctrl+V) in the **Data Points** selecting the first field.

Plastic Strain	True stress (Pa)
0	670081300
0,005	781333363,3

User  
Table data

Plastic Str	True stress (Pa)
0	670081300
0.005	781333363.3
0.01	863231287.4
0.015	916832288.5
0.02	955327927.3
0.025	984104374.3
0.03	1006215309
0.035	1023609047
0.04	1037597375
0.045	1049089413
0.05	1058726585
0.055	1066967202
0.06	1074142058
0.065	1080492057
0.07	1086194154
0.075	1091379477
0.08	1096146098
0.085	1100568094
0.09	1104702016
0.095	1108591538
0.1	1112270797
0.11	1119101303
0.12	1125353035
0.13	1131133820
0.14	1136520361
0.15	1141569748
0.16	1146326115
0.17	1150824639
0.18	1155094031
0.19	1159158171

Paste from xls

True Strain	True Stress	
1	0	670.081 MPa
2	0.005	781.333 MPa
3	0.01	863.231 MPa
4	0.015	916.832 MPa
5	0.02	955.328 MPa
6	0.025	984.104 MPa
7	0.03	1006.22 MPa
8	0.035	1023.61 MPa
9	0.04	1037.6 MPa
10	0.045	1049.09 MPa
11	0.05	1058.72 MPa



## Material Database(2) Material Create Demo

### Step 4

- Enter **FLC** Tab.
- Set the **FLC** to Calculate.
- Enter Thickness as 1.2 mm.
- Click on **Update** .
- Select material, Right Click and Pick **Add to user Material Library** to save the material to your library (optional).
- Click **Close** to dismiss the material dialog

$$FLC0 = ( 0.23 + 0.146 * t ) * n / 0.21 )$$

The screenshot shows the 'Materials' dialog box in Altair Inspire. The 'My Materials' tab is selected, and a tree view shows 'Steel\Usr' highlighted. A context menu is open over 'Steel\Usr' with options 'Add to User Material Library' and 'Delete from My Materials'. The right panel shows 'Name: UserMat1', 'Type: Steel', and the 'FLC' tab selected. The 'FLC' dropdown is set to 'Calculate' and 'Thickness' is '1.20 mm'. A plot of Major True Strain vs. Minor True Strain is shown at the bottom right.



# Material Database(2) Material Create Demo Video

The screenshot displays the Altair Inspire Form 2019 software interface on the left and a Microsoft Excel spreadsheet on the right. The spreadsheet contains material property data for uniaxial tension tests and plastic stress-strain curves.

**Uniaxial tension test data**

Tensile direction from RD	Young's Modulus (GPa)	$\sigma_{0.2}(MPa)$	$\sigma_{1.0}(MPa)$	Tensile Strength (MPa)	Uniform Elongation (%)	R-Value
0°	186	684.2	870.8	1017.2	9.4%	0.691
45°	191	676.6	863.4	1007.3	9.0%	1.050
90°	208	701.5	898.0	1052.3	9.4%	0.959

**Plastic Str: True stress (Pa)**

0	670081300
0.005	781333363.3
0.01	863231287.4
0.015	916832288.5
0.02	955327927.3
0.025	984104374.3
0.03	1006215309
0.035	1023609047
0.04	1037597375
0.045	1049089413
0.05	1058726585
0.055	1066967202
0.06	107442059
0.065	1080492057
0.07	1086194154
0.075	1091379477
0.08	1096146098
0.085	1100568094
0.09	1104702016
0.095	1108591538
0.1	1112270797
0.11	1119101303
0.12	1125353035
0.13	1131133820
0.14	1136520361
0.15	1141569748
0.16	1146326115



# QUESTIONS & ANSWERS

